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TRANSLATION OF

Some Hypotheses on the Relations between Solar Activity and Atmospheric Circulation

by

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Many studies have already been dedicated to the problems of how solar activity influences the weather. The overwhelming majority of those works consist, on the one hand, of statistical comparisons of separate parameters, characterizing the state of the sun and, on the other hand, of the earth's atmosphere. In the various studies, efforts have been made to foretell the weather on the basis of solar data by the numbers of sunspots (Ex. 1), then through the index of recurrence, and recently by correlation between the intensity of red and green coronal lines (2).

The studies giving an account on the physical schemes of the interaction of the sun are incomparably less in the troposphere, in spite of their urgent necessity. As a matter of fact, the basic reason arises from the insufficiency and the inaccuracy of our data on the properties of upper layers of the atmosphere. In relation to this, the available ~~diagrams~~ schemes contain to a considerable extent many debatable theses. Nonetheless, each new hypothesis should be welcomed at each given stage, as an element brought to the experiments of its definition or to far more perfect substitutions. The present study is dedicated to the examination of some of its essential schemes of influence and to an approximation of the possible variable.

One of the earliest hypotheses whose defender was P. P. Priedtietahenskiji seems to be a condensed theory. It is based on the assumption that an increase of solar activity is accompanied by a rise in the number of nucleus condensation in the atmosphere, and consequently by a much smaller increase of liberation of energy of humidity instability. Indeed, P. P. Priedtet-shenskiji showed, for instante, (p. 293), that precipitation and storms over central Asia fluctuate at a period of the 27th day of the solar cycle. Starting from the premise that unpon the loss of stability there arises a vertical convection, in 1949 there appeared one of the first theoretical attempts to link oscillations of pressure and temperature with solar activity, if we suppose that the latter (solar activity) determines a change of the coefficient of vertical mixing. It would be appropriate to note that criticism of the condensation theory usually resulted in the fact that solar activity should increase the ionization of the upper layers and water vapor condenses on ions at only a 4-fold collision (?) that can hardly be expected in the atmosphere. It is often referred about this to the study of Wilson.

Yet, in the quoted work, Wilson shows on page 419 that through irradiation of humid air by intensive U.V. light, fog appeared even without any kind of preliminary dilution, i.e., without collision and then even in the saturated air, when relative humidity was lower than 90% and higher than 50%. The nucleus of condensation creat~~ing~~ the UV light had no electric charge and remained several minutes, even several hours, after the irradiation, dependent on the intensity of the light.

It is interesting to notice that with rocket data from the limit of the atmosphere, the level of intensity of Lyman U.V. lines of 1216 Å. sometimes fall from the average of 5 $\frac{\text{ergs}}{\text{cm}^2\text{cek}}$ to 0.1 $\frac{\text{ergs}}{\text{cm}^2\text{cek}}$ (1952), i.e., oscillates 50 times. Though these oscillations of radiation were not linked to visible solar flares, they can, nonetheless, be reflected in the change of contents of the nucleus condensation number, in conformity with Wilson's experiment. Thus, the possible realization of the condensation theory is supported by the results of laboratory experiments, as well as by the rocket data and the inquiries which were received as conclusions after the solution of hydro-thermodynamic problems.

Of course, the processes of condensation in the atmosphere can activate the nucleus of condensation, crystallization and others.. Our investigations made in common with A. V. Tshili confrmed the conformity of Bowen's conclusions on the influence of cosmic dust on precipitation. Along with the photochemical activity of solar rays during solar explosions, a change of temperature in the highest layers of the atmosphere may occur. Thus, at Slutska, for example, temperature rises at the altitude of 5 km during the appearance of calcium floccula on the sun. It is possible that the likely explanation for an increase in temperature at such low levels is a liberation of latent heat of evaporation, provoked by solar activity. A considerable effect is observed in the layers of the ionosphere during sharp increases of U.V. radiation. After this a rise of temperature may be of about 500° (page 273). At the same time, there will appear in the ionosphere temperature gradients and pressures corresponding to a greater magnitude than in the troposphere. The result is that there arise greater winds than in the lower layers. At night the significance of temperature gradients inside of non-illuminated areas should fall and, at the same time, decrease the pressure gradients and the wind speed. This condition agrees with the observed fact of the after-midnight decrease of the drift speed of the ionized trails of meteors and silvery clouds varying from 65 m/sec until midnight to 32 m/sec after midnight.

Recently, V. V. Shuleikin and L. A. Korneva, coming out of the hypothesis on sharp increases of free positive charges in the ionosphere during solar explosions, reached the conclusion that sharp and self-forming fluctuations of the wind speed in the upper atmospheric layers could possibly happen (9). To the difference of much earlier hydrodynamic works, A. A. Dmitrieva, later on than L. R. Rakipov, not introducing electrodynamic focus but, in contrast, works where for average conditions in the E, E, and F_2 layers with the influence of the magnetic field seemed possible to neglect, shows that in the case of very strong increases of ionization the circulation processes of the upper atmosphere can change on account of the influence of the earth's magnetic field on the stream of ionized air.

Whatever the acceleration mechanism of circulation on the upper layers is, it seems interesting to compare the extent of the difference of influence in the speeds at high altitude with ~~inferior~~ lower atmospheric layers.

Therefore, it would be appropriate to examine the double layer problem with the purely zonal relative gradient of pressure, fitting linearly to the tropopause $\bar{H}$ and then decreasing to zero at a level Q times greater than the altitude of the tropopause $\bar{H}$.

At the altitude $S\bar{H}$ the complex, unmeasured speed $U = \bar{u} + i\bar{v}$ is supposed to be given and equal to $\bar{V}$. We will search for the influence of the magnitude $\bar{V}$ on the velocity of the tropopause. In introducing unmeasured variable by analogy (p. 64): $l = \sqrt{\frac{k_0 + kH}{\Omega \cos\theta}}$, $\bar{H} = \frac{H}{l}$; $\bar{z} = \frac{z}{l}$, $\bar{u} = \frac{u_0}{W}$ $\bar{V} = \frac{u_0}{W}$

$$\bar{K}_z = \frac{k_0}{k \cdot l} + \bar{z}, \quad W = \frac{1}{\rho \cdot r \cdot 2\Omega \cos\theta} \frac{\partial p}{\partial \theta} \text{ when } z = H \qquad (1)$$

we come to the system of equalization:

$$\frac{d}{d\bar{z}}\left[\bar{K}_z \frac{dU_1}{d\bar{z}}\right] + i \cdot 2\bar{K}_H \cdot U_1 = i\left[-a_\theta + b_\theta \bar{z}\right] \text{ when } 0 < \bar{z} < \bar{H} \qquad (2)$$

$$\frac{d}{d\bar{z}}\left[\bar{K}_z \frac{dU_2}{d\bar{z}}\right] + i \cdot 2\bar{K}_H \cdot U_2 = i\left[-a_\theta + b_\theta \cdot \bar{H}\right] \frac{Q\bar{H} - \bar{z}}{(Q-1)\bar{H}} \text{ when } \bar{H} < \bar{z} < Q\bar{H} \qquad (3)$$

with the condition limit: $U = 0$ when $\bar{z} = 0$

$U_2 = U_1$ when $\bar{z} = \bar{H}$

$$\frac{dU_1}{dz} = \frac{dU_2}{dz} \text{ when } \bar{z} = \bar{H} \quad \text{and } U_2 = V \text{ wh. } \bar{z} = SH \tag{4}$$

The solution of the system (2), (3) has the aspect

$$U = a + b\bar{z} + c J_0(\zeta_z) + d \cdot H_0(\zeta_z) \tag{5}$$

where a, b, c, d, ~~some~~ are constants, and Bessel and Hankel functions of the zero order $\zeta = 2\sqrt{2 k_H k_z}\sqrt{z}$

(6)

with the argument.

Not reducing for the conciseness of the whole solution, let us write its established and maintained $\bar{V}$. Thus we have:

(7)

If for the numerical estimation one takes $k = 10^{-2}$ $\frac{cm}{sec}$, which is obtained to interpolate the value of the coefficient of kinematic viscosity in a straight line from the value 10^4, given at the magnitude 100 km, to the zero at the earth, then the arguments of the function (7) become so considerable that it is possible to use the asymptotic formulae. Then one has roughly

(8)

where

The magnitude order of the argument of the exponent is at the tropopause level, if s = 2 is perfectly equal to 10^2. Consequently, the influence on speed changes is even at the double magnitude of the tropopause, to the tropopause speed, proves to be insignificant (about $10^{-10}\bar{V}$).

It is only arbitrarily that the increased vertical coefficient of turbulent viscosity at the tropopause level of about 3 (until 10^7 $\frac{cm^2}{sec}$) can be corrected to an order of 5%, which corresponds to $\Delta U_\lambda = 5$ m/sec,. With $\Delta V = 100$ m/sec. We do not possess the basis necessary to have such increased turbulence coefficients and thus it would be appropriate to look for the other mechanism of influence of solar activity on the circulation in the tropopphere.

In that case, it is convenient to use the rule obtained from the study of convective procpases on rotating models. To the difference of non-rotating models with liquids and gases, when the characteristical movement comes back into the center of each convective cell, does not take the shape of warm currents, there occurs an intensive process of heating from below or of cooling from above. In the first case, an ascending stream arises in the center; in the second, a descending one, though, in both cases, the entire convective cell (taken as a whole) will have to carry the heat upward to the condenser. One may suppose that in the earth's atmosphere there is a place of similar regularity during the general transport of heat from the overlying surface. The form of convective disturbance of equilibrium is determined by the level of the greatest temperature gradients. By an increase in temperature of the high layers, on account of greater intensive irradiation of their U.V. rays, it is appropriate to wait for the prevalence of cyclonic earth circulation, which at high altitudes may change sign with an anticyclone thanks to the alteration of air density. Indeed, after Friedman's equation for axially symmetric problems in the barotropic average which is in the polar system of coordinates, we write:

(9)

In the case when data are at the level h of radial u and vertical w the speed component is

(9a)

The relative turbulence at level z is:

(10)

where

h = initial level for which there is a small magnitude over the earth surface.

If, for example, at the level h, the cyclonic turbulence is approximately

out of the qualitative formula (10) we obtain

which in magnitude

where

with $\bar{w}(z)$ = constant, the relative turbulence disappears and ~~higher~~ there is an anti-cyclone.

By a decreased irradiation and cooling of the U.V. radiation in the upper layers, it is possible to expect a formation of descending movement of cells in the center, ~~through~~ though the further growth of such circulations is not obvious.

It is possible that some of their approximation may receive from the scheme of L. R. Rakopov analogous examination, but only with a physical approximation according to the formula type (10) for the level of the change circulation sign.

Of course, the noted change in zonal circulation of the earth and Jupiter during the fluctuation of solar activity remains without explanation.

This phenomenon may be qualitatively described, if it is suggested that changes in atmospheric temperatures related to solar activity, brings to radical dilatation of the gaseous envelopes at the speed of

(11)

For purely zonal movements observed we use a cylindrical stationary system of coordinates whose origin coincides with the center of the earth, and the axis z is directed along the axis of rotation. Thus, all parameters of the state can be determined after the system of non-linear equations

direction of movement (12)

(13)

direction of continuity

(14)

equation of state

(15)

eaution of warmth transfer

(16)

introducing non-linear equation characteristics.

(17)

and supposing that with

we find for density, zonal speed and pressure the corresponding expressions

(18)

(19)

(20)

We can easily see, from the formulae (18)-(20), that simple sinusoidal fluctuations u provoke from time to time pressure fluctuations of harmonics in the series. This agrees with the inographic results with double fluctuations of macroweather during one cycle of solar activity.

The estimation of zonal speed changes are carried out by the formula (19) under the condition that at the level of 10 km the amplitude of the vertical speed components should be $1 \frac{cm}{sec}$ and that the maximum of initial speed comes to that magnitude. The estimation showed that at a level of 20 km, zonal speed oscillations can reach the order of $10 \frac{m}{sec}$. Below the level of 10 km deviations have an opposite sign and less magnitude.

To sum up, we can conclude that each of the considered hypotheses does not pretend to universality and only allows to explaining some of the noticed relations between solar activity and the processes of the earth's atmosphere. It is necessary to accumulate supplementary data on the existence of the upper layers and their fluctuations from time to time in order to build a more harmonious and complete theory. It is possible that we might succeed in getting such material in the International Geophysical Year.